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FLIGHT EVALUATION OF AN ACOUSTIC ORIENTATION INSTRUMENT (AOI). K.K. Gillingham* and D.C. Teas. Armstrong Laboratory, Brooks AFB TX 78235-5000 and KRUG Life Sciences, San Antonio, TX 78279-0644.

INTRODUCTION. An AOI provides an auditory display of primary flight parameters, in theory allowing the pilot to maintain spatial orientation while visually occupied with other tasks. A flight simulator-tested AOI, which displays airspeed and vertical velocity as variable auditory images, and bank angle as lateralization of those images, was evaluated in flight in a Beech Queen Air aircraft. METHODS. The performance of 8 instrument-rated pilots during five experimental maneuvers (straight and level, 30° banked turn, steep turn, level-off from descent, and recovery from a disorienting maneuver) under four conditions (instrument hood, hood + AOI, blind, and blind + AOI) was measured with respect to absolute vertical velocity and bank angle deviations (mean, RMS, and variance). ANOVA and post-hoc statistical comparisons of the four conditions were accomplished. RESULTS. In all maneuvers the blind + AOI condition resulted in significantly better ($p<0.05$) bank angle control than was obtained in the blind-only condition, and bank angle control in the blind + AOI condition was not significantly different from that obtained under either hood condition. Although vertical velocity control tended to be better in the blind + AOI than in the blind-only condition in most maneuvers, statistical significance was reached only in straight and level flight. CONCLUSION. The AOI enables a pilot to maintain bank angle control in the absence of vision. Its potential to aid in vertical velocity control is also evident, but the vertical velocity display needs to be improved.

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DYNAMICS OF THE G-EXCESS ILLUSION. K. A. Baylor*[1], M. Reschke*[2], F. E. Guedry*[3], B. J. McGrath*[1] and A. H. Rupert*[1]. 1. Naval Aerospace Medical Research Laboratory, Pensacola, FL 32508-5700. 2. NASA, Johnson Space Center, Houston, TX 77058. 3. University of West Florida, Pensacola, FL 32514.

INTRODUCTION. The G-excess illusion is increasingly recognized as a cause of aviation mishaps especially when pilots perform high-speed, steeply banked turns at low altitudes. Centrifuge studies of this illusion have examined the perception of subject orientation and/or target displacement during maintained hypergravity with the subject's head held stationary. The transient illusory perceptions produced by moving the head in hypergravity are difficult to study onboard centrifuges because the high angular velocity ensures the presence of strong Coriolis cross-coupled semicircular canal effects that mask immediate transient otolith-organ effects. The present study reports perceptions following head movements in hypergravity produced by high-speed aircraft maintaining a banked attitude with low angular velocity to minimize cross-coupled effects. METHODS. Fourteen subjects flew on the NASA KC-135 were exposed to resultant gravity forces of 1.3, 1.5, and 1.8 G for 3-min periods. On command, seated subjects made controlled head movements in roll, pitch, and yaw at 30-s intervals both in the dark and with faint targets at a distance of 5 ft. RESULTS. Head movements produced transient perception of target displacement and velocity at levels as low as 1.3 G. Reports of target velocity without appropriate corresponding displacement were common. At 1.8 G when yaw head movements were made from a face down position, 4 subjects reported oscillatory rotational target displacement with fast and slow alternating components suggestive of torsional nystagmus. Head movements evoked symptoms of nausea in most subjects with 2 subjects and 1 observer vomiting. CONCLUSIONS. The transient percepts present conflicting signals, which introduce confusion in target and subject orientation. Repeated head movements in hypergravity generate nausea by mechanisms distinct from cross-coupled Coriolis effects.

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NATURE OF THE G EXCESS ILLUSION AS PRODUCED ON A RESEARCH CENTRIFUGE

T. L. Chelette*, E. J. Martin, R. L. Esken. Armstrong Laboratory, Wright-Patterson Air Force Base, OH

INTRODUCTION: The G excess illusion is described as an exaggerated sensation of self-tilt due to the increased shear forces placed on the otolith organs when the head is tilted under sustained G_z. The experiments described herein were designed to clarify the perceptual confounds of measuring such an illusion and to quantify the extent of the illusion on the Dynamic Environment Simulator, a human centrifuge. METHODS: Twelve subjects reported perceived location of the horizon through a gimbaled mechanism surrounding their right hand while performing a head aiming task using a helmet mounted display. Phase I placed the subject at a variety of attitudes. Phase II placed the torso at a variety of angles while maintaining the head at horizontal. Phase III repeated the positions of Phase II while at 3 G_z. Phase IV varied the head position and the G level while maintaining the torso aligned with the G_z vector. RESULTS: In the first three phases the following comparisons of mean errors showed no statistically significant differences; Phase I - pitch vs roll axis, head at 0° vs 45° (both axes), pre vs post training (both axes, both head angles); Phase II - torso at 0° and head at 45° vs reverse condition, torso and head at 0° vs torso at -45° and head at 0°; torso at -45°, -30° or +30° and head at 0° vs torso and head at 0°; Phase III - 3 G_z vs 1 G_z for torso at 0°, or +30° and head at 0° (both axes). Statistically significant increases in error at 3 G_z vs 1 G_z were observed when the body was pitched backward in the -30° and -45° positions and head at 0°. CONCLUSIONS: In this experimental paradigm, the following confounds have been shown to have no independent effect on the mean error in reported attitude: disparate sensitivity to roll axis vs pitch axis, repeated training with digital feedback, and haptic sensation of the gravity vector at 1 or 3 G_z. G_z level has been shown to have an error inducing effect when the neck is extended while keeping the head level.

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THE EFFECT OF VISUAL SCENE INFORMATION ON THE SOMATOGRAVIC ILLUSION. F.H. PREVIC, D.C. VARNER, AND K.K. GILLINGHAM*. Armstrong Laboratory, Brooks AFB, TX 78235-5000; Southwest Research Institute, San Antonio, TX 78298-2224

INTRODUCTION. The somatogravic illusion (SGI) occurs when a shift in the resultant gravitoinertial force vector created by a sustained linear acceleration is misinterpreted as a change in pitch or bank attitude. Since the SGI typically occurs under degraded visual conditions, this study attempted to determine which visual scene cues are most effective in overcoming the SGI. METHODS. Nine subjects (seven pilots) were exposed to 5.67 m/s^2 acceleration (+30 deg pitch SGI) for 30 s in the Armstrong Laboratory's Vertifuge. They experienced the SGI both with their eyes closed and while viewing visual scenes depicting acceleration over a shoreline through a wide field-of-view (90 x 60 deg) head-mounted display. The scenes contained horizon, perspective, texture, and color cues in both isolation and various combinations. Subjects indicated the direction of "down" during the final 7 s of each trial, and also rated the amount of linear vection produced by the scenes. RESULTS. None of the scenes significantly reduced the magnitude of the SGI relative to the eyes-closed pitch illusion (+26.6 deg). Significant vection was induced by some scenes, but it did not correlate with the ability of the scenes to reduce the SGI, even in the most visually dependent subjects. CONCLUSION. The ability of low-cost head-mounted visual displays to reliably reduce the magnitude of the SGI and other disorientation illusions remains uncertain. The capability to elicit vection may not be sufficient for overcoming the SGI.

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SOMATOGYRAL ILLUSION IN THE PITCH, ROLL AND YAW PLANE. H. Onus*, C. R. Wilpizeski* and G. Li. Environmental Tectonics Corporation, Southampton, PA and Jefferson Medical College, Philadelphia, PA

INTRODUCTION. After termination of constant velocity rotation, Jones and Kowalsky found differences in the persistence of the somatogyral illusion for pitch, roll and yaw. These differences may have been a consequence of the interaction between neck proprioceptors and the semicircular canals. We controlled neck tension by using whole-body rotation around the subject's X and Y axis. METHODS. With heads fixed and eyes closed, male volunteers were exposed to 6 deg/sec constant velocity rotation for a period of 60 seconds. They were asked to respond as soon as they perceived the onset and termination of rotation. RESULTS. With neck tension controlled, the median durations of the per- and postrotational somatogyral illusion were progressively greater for pitch, roll and yaw. Persistence of perceived rotation was longer in all three planes during rotation than after. Only 61% of the subjects could accurately identify the direction of roll. CONCLUSIONS. The duration of the somatogyral illusion differs for roll, pitch and yaw. This difference cannot be explained completely by physiological interaction between neck proprioception and semicircular canals.

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RESEARCH AND DEVELOPMENT : THE INTEGRATION OF COMPUTER BASED MEDICAL TECHNOLOGY INTO THE AEROMEDICAL EVACUATION SYSTEM OF THE 21 CENTURY MSgt L.D. Tripp Jr.*, 356th Tactical Airlift Squadron, Rickenbacker ANGB, 43217

INTRODUCTION: Aeromedical evacuation is on the brink of some extraordinary advances in patient care technology. With the explosion of biomedical technology over the past 15 years, a plethora of computer based patient assessment technologies have emerged. These new technologies present the flight nurse corps with endless research opportunities in the area of advanced medical equipment applications in the aircraft environment. **METHODS:** Some of the current off-the-shelf items which may apply to in flight patient care include: 1) pulse oximetry, for non-invasive arterial oxygen saturation measurement, 2) automated blood pressure monitoring , 3) infrared digital thermometers, and 4) transcrainal Doppler, for measuring cerebral blood flow. Research in to the application of these devices will require the development of experimental protocols, in flight test and evaluation, data collection and analysis, and plans for incorporating these devices into the future equipment and training requirements. **RESULTS:** An increase in the quality of in flight patient care will be the major benefit derived from this process. **CONCLUSION:** The result of these efforts will culminate in the transformation of aeromedical patient care into the 21st century.

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(Panel Overview Abstract)

SPACE STATION FREEDOM: EVOLUTION OF MEDICAL CAPABILITIES. R.D. Billica, M.D.*, and C.W. Lloyd, Pharm.D.

PANEL OVERVIEW: In the past year the Space Station Freedom program has advanced through a major restructuring effort and passed significant design milestones. The efforts to baseline medical functions have kept pace using a phased approach to providing new technologies and capabilities. This panel presents the results of recent efforts to solidify health care planning and provisions for the Space Station. Included are reports from clinical studies performed on Space Shuttle, KC-135 zero-gravity, and ground-based laboratories.

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Medical Care Capabilities for Space Station Freedom: A Phased Approach, C. R. Doarn and C. W. Lloyd, NASA and KRUG Life Sciences, Medical Operations Branch, Johnson Space Center, Houston, TX

As a result of Congressional mandate Space Station Freedom (SSF) was restructured. This restructuring activity has affected the capabilities for providing medical care on board the station. This presentation addresses the health care facility to be built and used on the orbiting space station. This unit, named the Health Maintenance Facility (HMF), is based on and modeled after remote, terrestrial medical facilities. It will provide a phased approach to health care for the crews of SSF. Beginning with a stabilization and transport phase, HMF will expand to provide the most advanced state of the art therapeutic and diagnostic capabilities. This presentation details the capabilities of such a phased HMF. As Freedom takes form over the next decade there will be ever-increasing engineering and scientific developmental activities. The HMF will evolve with this process until it eventually reaches a mature, complete, stand-alone health care facility that provides a foundation to support interplanetary travel. As man's experience in space continues to grow so will the ability to provide advanced health care for Earth-orbital and exploratory missions as well.

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A PROTOTYPE CREW MEDICAL RESTRAINT SYSTEM (CMRS) FOR SPACE STATION FREEDOM. S.L. Johnston*, F.T. Eichstadt, and R.D. Billica*. KRUG Life Sciences and Medical Operations, NASA Johnson Space Center, Houston, Texas.

The CMRS is a prototype system designed and developed for use as a universally deployable medical restraint/workstation on Space Station Freedom (SSF), the Shuttle Transportation System (STS), and the Assured Crew Rescue Vehicle (ACRV) for support of an ill or injured crewmember requiring stabilization and transportation to earth. The CMRS will support all medical capabilities of the Health Maintenance Facility (HMF) by providing a restraint/interface system for all equipment (Advanced Life Support packs, defibrillator, ventilator, portable oxygen supply, IV pump, transport monitor, transport aspirator, and intravenous fluids delivery systems), and personnel (patient and crew medical officers). It must be functional within the STS, ACRV, and all SSF habitable volumes. The CMRS will allow for medical capabilities within CPR, ACLS, and ATLS standards of care. This must all be accomplished for a worst case transport time scenario of 24 hours from SSF to a definitive medical care facility on earth.

A presentation of the above design prototype with its subsequent one year SSF/HMF and STS/ACRV high fidelity mock-up ground based simulations testing will be given. Also, parabolic flight and underwater Weightless Environmental Test Facility evaluations will be demonstrated for various medical contingencies. The final design configuration to date will be discussed with future space program impact considerations.

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DELIVERY OF CARDIOPULMONARY RESUSCITATION IN THE MICROGRAVITY ENVIRONMENT. M. R. Barratt* and R. D. Billica*. KRUG Life Sciences and Medical Operations, NASA Johnson Space Center, Houston, TX

INTRODUCTION. The microgravity environment presents several challenges for delivering effective cardiopulmonary resuscitation (CPR). Chest compressions must be driven by muscular force rather than by the weight of the rescuer's upper torso. Airway stabilization is influenced by the neutral body posture. Rescuers will consist of crewmembers of varying sizes and degrees of physical deconditioning from space-flight. Several methods of CPR designed to accommodate these factors were tested in the one g environment, in parabolic flight, and on a recent shuttle flight. METHODS. Utilizing study participants of varying sizes, different techniques of CPR delivery were evaluated using a recording CPR manikin to assess adequacy of compressive force and frequency. Under conditions of parabolic flight, methods tested included conventional positioning of rescuer and victim, free-floating "Heimlich-type" compressions, straddling the patient with active and passive restraints, and utilizing a mechanical cardiac compression assist device (CCAD). Multiple restraint systems and ventilation methods were also assessed. RESULTS. Delivery of effective CPR was possible in all configurations tested. Reliance on muscular force alone was quickly fatiguing to the rescuer. Effectiveness of CPR was dependent on technique, adequate restraint of the rescuer and patient, and rescuer size and preference. Free-floating CPR was adequate but rapidly fatiguing. The CCAD was able to provide adequate compressive force, but positioning was problematic. CONCLUSIONS. Delivery of effective CPR in microgravity will be dependent on adequate rescuer and patient restraint, technique, and rescuer size and preference. Free-floating CPR may be employed as a stop-gap method until patient restraint is available. Development of an adequate CCAD would be desirable to compensate for the effects of deconditioning.

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ADVANCED CARDIAC LIFE SUPPORT (ACLS) UTILIZING MAN-TENDED CAPABILITY (MTC) HARDWARE ONBOARD SPACE STATION FREEDOM. M. Smith, M. Barratt, C. Lloyd. NASA and KRUG Life Sciences, Inc. Medical Operations Branch, Johnson Space Center, Houston, Texas 77058.

INTRODUCTION. Because the time and distance involved returning a patient from space to a definitive medical care facility, the capability for Advanced Cardiac Life Support (ACLS) exists onboard Space Station Freedom. METHODS. In order to evaluate the effectiveness of terrestrial ACLS protocols in microgravity, a medical team conducted simulations during parabolic flight onboard the KC-135 aircraft. The hardware planned for use during the MTC phase of the space station was utilized to increase the fidelity of the scenario and to evaluate the prototype equipment. Based on initial KC-135 testing of CPR and ACLS, changes were made to the ventricular fibrillation algorithm in order to accommodate the space environment. Other constraints to delivery of ACLS onboard the space station include crew size, minimal training, crew deconditioning, and limited supplies and equipment. RESULTS. The delivery of ACLS in microgravity is hindered by the environment, but should be adequate. Factors specific to microgravity were identified for inclusion in the protocol including immediate restraint of the patient and early intubation to insure airway. External cardiac compressions of adequate force and frequency were administered using various methods. The more significant limiting factors appear to be crew training, crew size, and limited supplies. CONCLUSIONS. Although ACLS is possible in the microgravity environment, future evaluations are necessary to further refine the protocols. Proper patient and medical officer restraint is crucial prior to advanced procedures. Also, emphasis should be placed on early intubation for airway management and drug administration. Preliminary results and further testing will be utilized in the design of medical hardware, determination of crew training, and medical operations for space station and beyond.

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A SURGICAL SUPPORT SYSTEM FOR SPACE STATION FREEDOM. M. R. Campbell*, R. D. Billica*, and S. L. Johnston*. KRUG Life Sciences and Medical Operations, NASA Johnson Space Center, Houston, Texas.

INTRODUCTION. Surgical techniques in microgravity are being developed for the Health Maintenance Facility (HMF) on Space Station Freedom (SSF). This will be a presentation of the proposed surgical capabilities and ongoing hardware and procedural investigations. METHODS. Procedures and prototype hardware, which include a medical restraint system, a surgical overhead isolation canopy, a suction device, and a regional laminar flow device were evaluated. This was accomplished by realistic sterile surgical simulations involving both mannequins and animals during KC-135 parabolic flight and in a high fidelity ground based HMF mockup. RESULTS. Animal surgery in the environment of microgravity allowed the observation of unique arterial and venous bleeding characteristics for the first time. The ability to control bleeding and to prevent cabin atmosphere contamination was also demonstrated. CONCLUSIONS. The procedures and prototype hardware tested provided valuable information and should be investigated and developed further. The use of standard surgical techniques are possible in microgravity if the principles of personnel and supply restraint and operative field containment are adhered to.